Design and Analysis of an Improved Compact Catadioptric Cassegrain System with Multi-Edge Suppression and Depth-Assisted Imaging

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This study proposes an improved compact Cassegrain-based imaging system for ultra-telephoto applications. To reduce the trade-off among focal length, structural length, and central obscuration, a large-aperture refractive element is inserted between the primary and secondary mirrors and reused through multiple passes, while a small terminal negative–positive lens pair further extends the effective focal length and back focal distance. To suppress image degradation under non-ideal illumination, a division-of-labor strategy is introduced: a blue-noise microdot annulus is used to weaken directional diffraction peaks, and a V-groove light-trapping band is used to reduce grazing-incidence stray light and background uplift. In addition, the system is extended from main imaging to depth-assisting imaging by combining a functional secondary mirror with polarization detection. The O-polarized channel is used for main imaging, while E-polarized auxiliary channels provide depth-related information through defocus and spot-size differences, with consistency verification improving reliability. Simulations and experiments show that the proposed system improves compactness, contrast robustness, and depth-assisting capability while preserving usable main imaging performance.

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